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ELECTROTECHNICAL
COMMISSION

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TS 61400-26-1

WIND TURBINES -
Part 26-1: Time based availability for wind turbines

Committee Draft – IEC 61400-26-1 Technical Specification

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND TURBINES -

Part 26-1: Time base availability for wind turbine generating systems

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- The subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 61400-26, which is a technical specification, has been prepared by IEC technical committee 88: Wind Turbines.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
88/XX/DTS	88/XX/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61400-26 series, under the general title *Availability for wind turbines and wind power plants* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual edition of this document may be issued at a later date.

Part 26-1: Time based availability for wind turbines

1 Project scope

The scope of the project is to achieve the objectives stated in the NP88/304e approved by the TC88 meeting in Copenhagen, May 2007. Defined as: "The technical specification shall define generic terms of wind turbine systems and environmental constraints in describing system and component availability, lifetime expectancy, repairs and criteria for determining overhaul intervals. Furthermore the specification shall define terminology and generic terms for reporting wind power based generating unit reliability and availability measurement. A generating unit includes all equipment up to the termination point defined in the distribution code (grid code) agreed between the generation party and the distribution / transmission party. Reliability encompasses measurement of the ability of the wind turbines to perform their intended function. Availability measurements are concerned with fractions of time a unit is capable of providing service, taking environmental aspects into account. Environmental aspects would be wind and other weather conditions, as well as grid and substation conditions. In case further common definitions are required, coordination with other groups (see next paragraph) is highly recommended – to obtain a set of definitions relevant to electricity generation using wind power, consistent with IEC 61400-26-1." ¹

The project scope is accomplished by separating the results of the technical specification into three parts:

1. TS 61400-26-1 specify terms for time based availability of a wind turbine generating system.
2. TS 61400-26-2 specify terms for production based availability of a wind turbine generating system¹
3. TS 61400-26-3 specify terms for time and production based availability of a wind power plant²

1.1 Scope for IEC 61400-26-1

The scope of the TS 61400-26-1 is to define generic information categories to which fractions of time can be assigned for of a wind turbine generating system (WTGS) considering internal and external conditions based on fraction of time and specifying the following:

- generic information categories of a WTGS considering availability and other performance indicators
- information category priority in order to discriminate between concurrent categories
- entry and exit point for each information category in order to allocate designation of time
- informative annexes including:
 - examples of optional information categories

¹ Development of this part to be agreed with IEC TC88

² Development of this part to be agreed with IEC TC88

- examples of algorithms for reporting availability and performance indicators
- examples of application scenarios

2 Introduction

The intention of this technical specification is to define a common basis for exchange of information on performance indicators between owners, utilities, lenders, operators, manufacturers, consultants, regulatory bodies, certification bodies, insurance companies and other stakeholders in the wind power generation business. This is achieved by providing an information model specifying how time designations shall be split into information categories. The information model forms the basis for how to allocate time for reporting availability and reliability indicators.

The content of the present document is separated into the following clauses.

Clause 3 includes all normative references applied to this specification.

Clause 4 includes all abbreviations applied in the specification.

Clause 5 includes all definitions of relevance for the specification.

Clause 6 gives an introduction to the information model defined for a WTGS when reporting availability and reliability indicators based on fraction of time.

Clause 7 gives the detailed specifications for the mandatory information categories defined for a WTGS when information is available. The information category of a WTGS is specified with a definition, an entry point and an exit point for the information categories.

Clause 8 defines the situation when information is not available.

In addition this technical specification includes informational annexes.

Annex A describes optional information categories.

Annex B includes examples of time based availability indicators and proposed algorithms for the exchange of information on availability and reliability.

Annex C includes test scenarios applied for validation of the information model and specifications given in this document.

3 Normative references

IEC 60050-415 (1999): *International Electrotechnical Vocabulary - Part 415: Wind turbine generator systems.*

ISO 3977-9 (1999) *Gas turbine procurement – reliability, availability, maintainability and safety*

IEEE762-2006 *Standard definitions for use in reporting electrical generation unit reliability, availability and productivity*

IEC 61400-25-2(2006): *WIND TURBINES Communications for monitoring and control of wind power plants - Information Models*

IEC 61400-25-3(2006): *WIND TURBINES Communications for monitoring and control of wind power plants - Information Exchange Models*

IEC 61400-25-4(2008): *WIND TURBINES Communications for monitoring and control of wind power plants - Mapping to communication profiles*

IEC 61400-1, Ed.3 *WIND TURBINES - Design requirements*

4 Abbreviations

IA	Information Available category
IAO	Information Available Operative category
IAOG	Information Available Operative Generating category
IAOGFP	Information Available Operative Generating with Full Performance category
IAOGPP	Information Available Operative Generating with Partial Performance category
IAONG	Information Available Operative Nongenerating category
IAONGTS	Information Available Operative Nongenerating Technical Standby category
IAONGEN	Information Available Operative Nongenerating Out of Environmental Specification category
IAONGENC	Information Available Operative Nongenerating Out of Environ. Spec. optional category calm winds
IAONGENO	Information Available Operative Nongenerating Out of Environ. Spec. optional category other envir.
IAONGEL	Information Available Operative Nongenerating Out of Electrical Specification category
IAONGRS	Information Available Operative Nongenerating Requested Shutdown category
IAN	Information Available Nonoperative category
IANSM	Information Available Nonoperative Scheduled Maintenance category
IANPCA	Information Available Nonoperative Planned Corrective Actions category
IANFO	Information Available Nonoperative Forced Outage category
IANSS	Information Available Nonoperative Suspended category
IAFM	Information Available Force Majeure category
IU	Information Unavailable category
SCADA	Supervisory Control and Data Acquisition
WTGS	Wind Turbine Generating System
TT	Total time

5 Definitions

The relevant definitions contained in ISO/IEC Guide and IEC 60050-415 are applicable. For the purpose of this document, the following terms and definitions also apply.

5.1 Availability

The fraction of a given operating period in which a WTGS is performing its intended services within the design specification.

5.2 Design specifications

The collection of precise and explicit information about requirements for a product design. It provides in-depth details about the functional and non-functional design requirements including assumptions, constraints, performance, dimensions, weights, reliability and standards. For example specifications and design considerations given in the IEC61400-1 standard define the process for producing design specifications for WTGSs.

5.3 External conditions

Conditions outside of the WTGS that affect the operation of the WTGS, for example (i) out of environmental specification and (ii) out of electrical specification.

5.4 Permanent storage

Type of computer storage that keeps the data or its contents regardless of whether the power is turned off or if the storage device is moved to another computer. The most commonly used permanent storage is the computer hard disk drive.

5.5 Reliability

Reliability is the probability that a component part, equipment, or system will satisfactorily perform its intended function under given circumstances for a specified period of time.

5.6 Repair

The activity whereby components of a system are restored to a safe operating condition following an unpredicted or unforeseen failure.

5.7 Retrofit

The incorporation of new technology or new design parts resulting from an approved engineering change to an already supplied item.

5.8 Total Time

Total time is the total calendar time of the period selected.

6 Information model

The information model is comprised of different information categories. All calendar time shall be distributed into these information categories.

Each information category has an associated entry point and exit point. The entry point describes the criteria that have to be fulfilled to allocate time into a specific information category. The exit point describes the criteria to be fulfilled to end time allocation to a specific information category.

The information model is split into five levels and the hierarchy shall be understood from level one to level five i.e. all attributes of overlaying information categories are inherited by underlying information categories. The time designations are allocated at the lowest mandatory level. Overlaying information categories shall contain the sum of the related information categories on the underlying level. The information categories are introduced in clause 6.1.

In case entry conditions are fulfilled concurrently for two or more information categories, time shall be assigned into the information category with the highest priority only. Information category priorities are described in more details in clause 6.3.

6.1 Information categories

Information categories are counters for accumulation of time periods with specified attributes defined for a WTGS with the purpose of exchange of information on availability.

Figure 1 is an overview of the information categories defined in this technical specification. The information model includes four mandatory and one optional level of information categories.

Compliance with this technical specification requires designation of time periods into the mandatory information categories defined in level 1 to level 4 as shown in Figure 1.

The optional information categories defined in level 5 are not required to be compliant with this specification; they are included to allow users to customize reporting details to meet their specific requirements. This specification imposes no limits on the number of optional information categories or levels added by the individual users. The optional information categories shown in Figure 1 are for illustrative purposes only and are described in Annex A. All optional information categories shall be located on level 5 or higher in order to be compliant with this technical specification.

Abbreviations for the various information categories are indicated in brackets with bold letters. The abbreviations are defined in clause 4.

6.2 Limitations

It is not in the scope of this technical specification to determine the method of information acquisition.

Information categories					
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Optional - description see Annex A Level 5	
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)		
			PARTIAL PERFORMANCE (IAOGPP)	Derated	
				Degraded	
		NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)		
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	Calm Winds	
				Other Environmental	
			REQUESTED SHUTDOWN (IAONGRS)		
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)		
		NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		Response
			PLANNED CORRECTIVE ACTIONS (IANOPCA)		Diagnostic
	FORCED OUTAGE (IANOFO)		Logistic		
	SUSPENDED (IANOS)		Failure repair		
			Scheduled Maintenance Planned Corrective Actions Forced Outage		
	FORCE MAJEURE (IAFM)				
INFORMATION UNAVAILABLE (IU)					

Figure 1 – Information category overview

The information categories are described in further details in clause 7, clause 8 and Annex A.

6.3 Information category priority

Time present in the information categories shall be exclusive and continuous. In case the conditions for allocating a time period to more than one information category are fulfilled at the same time, the information category priorities determine which category takes precedence for the allocation of the time period being considered. Assignment of priorities to the information categories provides a uniform and transparent method for designation of time.

The order of priorities as specified in Figure 2 is mandatory for compliance with this model. The priorities are ranked from one to twelve with one as the lowest and twelve as the highest priority. Priorities for optional information categories can be introduced for specific purposes. In such cases the mandatory priorities can be extended with a priority for the optional information category.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1
			PARTIAL PERFORMANCE (IAOGPP)	2
		NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6
	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11
INFORMATION UNAVAILABLE (IU)			12	

Figure 2 – Information category priority

7 INFORMATION AVAILABLE

Definition - The category INFORMATION AVAILABLE covers all time periods, during which information on the WTGS and external conditions is retrieved, logged and stored manually or automatically.

It is recognised that there may be circumstances when information is partially available. Qualification for INFORMATION AVAILABLE category requires enough information to confirm if the exit and entry points for all mandatory categories are met.

This category covers all mandatory information categories as depicted in Figure 3.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1
			PARTIAL PERFORMANCE (IAOGPP)	2
		NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6
	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11

Figure 3 – INFORMATION AVAILABLE category

Entry point – The WTGS operating status data is available and can be logged and stored

Exit point – The WTGS operating status data is not available and/or cannot be logged or stored.

7.1 OPERATIVE

Definition - The WTGS is in the category OPERATIVE when capable of performing generation function, regardless of whether it is actually generating and regardless of the capacity level that can be provided.

The OPERATIVE category is underlying the INFORMATION AVAILABLE category and has two underlying information categories as listed below and depicted in Figure 4.

- GENERATING – as defined in clause 7.1.1
- NON-GENERATING – as defined in clause 7.1.2

The OPERATIVE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1
			PARTIAL PERFORMANCE (IAOGPP)	2
		NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6

Figure 4 – OPERATIVE category

Entry point – The WTGS is able to perform the generation function, regardless of whether it is actually generating and regardless of the capacity level that can be provided. For example internal faults or alarms are resolved, maintenance is completed and other events such as force majeure are cleared.

Exit point – One or more turbine-internal faults, alarms or other constraints occur, preventing the turbine from providing its intended service.

7.1.1 GENERATING

Definition – The WTGS is converting wind energy into electrical energy and/or providing reactive compensation.

The GENERATING category is an underlying category of the OPERATIVE category and has two underlying mandatory information categories as listed below and depicted in Figure 5.

- FULL PERFORMANCE – as defined in clause 7.1.1.1
- PARTIAL PERFORMANCE – as defined in clause 7.1.1.2

The GENERATING information category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1
			PARTIAL PERFORMANCE (IAOGPP)	2

Figure 5 – GENERATING category

Entry point – The WTGS starts generating.

Exit point – The WTGS stops generating.

7.1.1.1 FULL PERFORMANCE

Definition - The WTGS is operative and generating according to design specifications with no technical restrictions or limitations which affect generation.

The FULL PERFORMANCE category is an underlying category of GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 6.

The FULL PERFORMANCE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAG)	FULL PERFORMANCE (IAOGFP)	1
			PARTIAL PERFORMANCE (IAOGPP)	2

Figure 6 – FULL PERFORMANCE category

Entry point – The WTGS starts generating with full performance.

Exit point – The WTGS stops generating with full performance.

7.1.1.2 PARTIAL PERFORMANCE

Definition – This category is obtained when the WTGS is operative and generating with technical restrictions or other limitations which affect generation.

The PARTIAL PERFORMANCE category is an underlying category of GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 7.

The PARTIAL PERFORMANCE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1
			PARTIAL PERFORMANCE (IAOGPP)	2

Figure 7 – PARTIAL PERFORMANCE category

Entry point – The WTGS starts generating with partial performance. An external or internal conditions exists which prohibits the WTGS from operating at specified active or reactive power levels.

Exit point – The WTGS stops generating with partial performance. All external and internal conditions which prohibit the WTGS from operating at a specified active and reactive power levels are cleared.

7.1.2 NON-GENERATING

Definition – The category NON-GENERATING is obtained when the WTGS is operative but not generating because one of the underlying information categories is active.

The NON-GENERATING category is an underlying category of OPERATIVE and has four predefined underlying mandatory information categories as listed below and depicted in Figure 8.

- TECHNICAL STANDBY – as defined in clause 7.1.2.1
- OUT OF ENVIRONMENTAL SPECIFICATION – as defined in clause 7.1.2.2
- REQUESTED SHUTDOWN – as defined in clause 7.1.2.3
- OUT OF ELECTRICAL SPECIFICATION – as defined in clause 7.1.2.4

The NON-GENERATING category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6

Figure 8 – NON GENERATING category

Entry point – The WTGS is not generating or it stops generating due to one of the circumstances described in the underlying information categories.

Exit point – All circumstances in all underlying categories are cleared.

7.1.2.1 TECHNICAL STANDBY

Definition – The category TECHNICAL STANDBY is defined as the periods where a WTGS is actively performing tasks required for generation.

This may include, but is not limited to, the following aspects:

- Safety loop test
- Component and system self testing
- Cable unwinding / untwisting
- Heating up or cooling down after a period of “out of environmental specification” on temperature
- De-icing after a period of “out of environmental specification” on ice build-up
- Ramp-up time – from a command to completion of command
- Dry out time after WTGS stop/pause with high humidity

The TECHNICAL STANDBY category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 9.

The TECHNICAL STANDBY category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6

Figure 9 – TECHNICAL STANDBY category

Entry point – The WTGS determines or receives a command that technical standby tasks have to be executed and subsequently executes one or more technical standby tasks

Exit point – The WTGS has completed all active technical standby tasks.

7.1.2.2 OUT OF ENVIRONMENTAL SPECIFICATION

Definition – The category OUT OF ENVIRONMENTAL SPECIFICATION is obtained when the WTGS is operative but not generating as the conditions of the natural environment are outside the design specifications.

Natural environmental conditions could include ambient temperature, wind speed, humidity, atmosphere acidity, dust, turbulence, air density etc.

The OUT OF ENVIRONMENTAL SPECIFICATION category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 10.

The OUT OF ENVIRONMENTAL SPECIFICATION category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6

Figure 10 – OUT OF ENVIRONMENTAL SPECIFICATION category

Entry point – One or more of the natural environment conditions change to be outside the WTGS design specification, prohibiting the WTGS from generating.

Exit point – All the natural environment conditions change to be within the WTGS design specification.

7.1.2.3 REQUESTED SHUTDOWN

Definition – The category REQUESTED SHUTDOWN is obtained when the WTGS is operative but not generating as it has been stopped by an external demand, which could be either local or remote.

This may include, but is not limited to, the following aspects:

- Safety related events (such as icing on blades)
- Manual stop
- Training
- Visits / demonstrations
- Bird / bat protection
- Sector management
- Thunderstorms
- Full curtailment
- Nuisance – noise
- Operator requested upgrades or improvements

REQUESTED SHUTDOWN category is mandatory.

The REQUESTED SHUTDOWN category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 11.

The REQUESTED SHUTDOWN category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6

Figure 11 – REQUESTED SHUTDOWN category

Entry point – The WTGS is requested to shut down by an external demand.

Exit point – All active external requests to shut down are cleared.

7.1.2.4 OUT OF ELECTRICAL SPECIFICATION

Definition – The category OUT OF ELECTRICAL SPECIFICATION is obtained when the WTGS is operative but not generating as the electrical conditions at the WTGS terminals are outside design specifications.

This may include, but is not limited to, the following aspects:

- Voltage
- Frequency
- Phase imbalance

The OUT OF ELECTRICAL SPECIFICATION category is an underlying category of the NON-GENERATING and has no predefined underlying mandatory information categories as depicted in Figure 12.

The OUT OF ELECTRICAL SPECIFICATION category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6

Figure 12 – OUT OF ELECTRICAL SPECIFICATION category

Entry point – One or more of the electrical conditions at the WTGS terminals change to be outside the design specifications, prohibiting the WTGS from generating.

Exit point – All the electrical conditions at the WTGS terminals change to be within the design specifications.

7.2 NON-OPERATIVE

Definition – The NON-OPERATIVE category covers all the situations when a WTGS is not capable of performing the generation function.

The NON-OPERATIVE category is an underlying category of the INFORMATION AVAILABLE and has four underlying mandatory information categories as listed below and depicted in Figure 13.

- SCHEDULE MAINTENANCE – as defined in clause 7.2.1
- PLANNED CORRECTIVE ACTIONS – as defined in clause 7.2.2
- FORCED OUTAGE – as defined in clause 7.2.3
- SUSPENDED – as defined in clause 7.2.4

The NON-OPERATIVE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11

Figure 13 – NON-OPERATIVE category

Entry point –Maintenance or repair work is required or one or more WTGS faults or alarms occurs, prohibiting the WTGS from performing the generating function.

Exit point – Any maintenance or repair work is completed and all WTGS faults or alarms are cleared and the WTGS is able to perform the generating function.

7.2.1 SCHEDULED MAINTENANCE

Definition – The category SCHEDULED MAINTENANCE is obtained during scheduled maintenance actions according to the WTGS manufacturer's maintenance specification.

If the specified scope cannot be completed within the specified time, excess time will be considered as FORCED OUTAGE. Time for additional scope may be identified as REQUESTED SHUTDOWN.

The SCHEDULED MAINTENANCE category is an underlying category of the NON-OPERATIVE and has no predefined underlying mandatory information categories as depicted in Figure 14.

The SCHEDULED MAINTENANCE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11

Figure 14 – SCHEDULED MAINTENANCE category

Entry point – The WTGS is stopped or prohibited from being operative with the intention of performing scheduled maintenance.

Exit point - The WTGS exit this category by manual intervention confirming that the scheduled maintenance has been interrupted or completed.

7.2.2 PLANNED CORRECTIVE ACTIONS

Definition – The category PLANNED CORRECTIVE ACTIONS is obtained during actions outside the scope of the maintenance strategy for a WTGS with the objective of retaining, restoring or improving a WTGS in order to perform generating function.

PLANNED CORRECTIVE ACTIONS typically includes, but are not limited to:

- retrofit
- condition based maintenance
- corrective actions
- inspections
- upgrades
- investigations of potential failures

The PLANNED CORRECTIVE ACTIONS category is an underlying category of the NON-OPERATIVE and has no predefined underlying mandatory information categories as depicted in Figure 15.

The PLANNED CORRECTIVE ACTIONS category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11

Figure 15 – PLANNED CORRECTIVE ACTIONS category

Entry point – The WTGS is stopped or prohibited from being operative with the intention of performing planned corrective actions.

Exit point - The WTGS exit this category by manual intervention confirming the planned corrective actions are interrupted or completed.

7.2.3 FORCED OUTAGE

Definition – The category FORCED OUTAGE is obtained when an immediate action to disable the generating function of the WTGS is required as unforeseen damage, faults, failures or alarms are detected. This can be detected manually or automatically.

The FORCED OUTAGE category is an underlying category of the NON-OPERATIVE and has no underlying mandatory information categories as depicted in Figure 16.

The FORCED OUTAGE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11

Figure 16 – FORCED OUTAGE category

Entry point – The WTGS is disabled from generating because of damage, faults, or failures or an alarm.

Exit point - The WTGS exits this category when causes for outage are cleared.

7.2.4 SUSPENDED

Definition - The category SUSPENDED covers all situations when activities in SCHEDULED MAINTENANCE, PLANNED CORRECTIVE ACTIONS and FORCED OUTAGE have to be interrupted or cannot be initiated due to conditions which compromise personal safety or equipment integrity.

The SUSPENDED category includes, but is not limited to:

- Access limitations because of e.g. high waves, ice, snow, storm
- Severe weather conditions, like lightning, tornados, hail
- Reduction of risks initiated by the activities like bush fire
- Public authorities' orders for suspension of the work because of personal safety
- Site working conditions are not meet.

The SUSPENDED category is an underlying category of the NON-OPERATIVE and has no underlying mandatory information categories as depicted in Figure 17.

The SUSPENDED category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11

Figure 17 – SUSPENDED category

Entry point – This category is entered by manual intervention when work is suspended according to conditions defined.

Exit point – this category is terminated by manual intervention when the conditions suspending the work have been cleared.

7.3 FORCE MAJEURE

Definition - The category FORCE MAJEURE covers all situations where an extraordinary event or circumstance beyond the control of the parties involved, prevents the parties from fulfilling their obligations.

FORCE MAJEURE is a common clause in contracts which essentially frees concerned parties from their liability or obligation when an extraordinary event or circumstance beyond the control of the parties occurs.

FORCE MAJEURE is not intended to excuse negligence or other malfeasance of a party, as where non-performance is caused by the usual and natural consequences of external forces or where the intervening circumstances are specifically contemplated.

The FORCE MAJEURE information category is underlying the INFORMATION AVAILABLE information category on level 2 and has no underlying mandatory information categories as depicted in Figure 18.

The FORCE MAJEURE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11

Figure 18 – FORCE MAJEURE category

Entry point – This category is entered by manual intervention when a force majeure situation is detected according to contract text.

Exit point – this category is terminated by manual intervention when a force majeure situation has been cleared according to contract text.

8 INFORMATION UNAVAILABLE

Definition - The category INFORMATION UNAVAILABLE covers all time periods when the category INFORMATION AVAILABLE is not applicable.

The INFORMATION UNAVAILABLE information category on level 1 and as such has no overlying information category. In addition this information category has no underlying mandatory information categories as depicted in Figure 19.

The INFORMATION UNAVAILABLE category is mandatory.

Information categories				
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory Priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1
			PARTIAL PERFORMANCE (IAOGPP)	2
		NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4
			REQUESTED SHUTDOWN (IAONGRS)	5
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6
	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8
		FORCED OUTAGE (IANOFO)		9
		SUSPENDED (IANOS)		10
	FORCE MAJEURE (IAFM)			11
INFORMATION UNAVAILABLE (IU)			12	

Figure 19 – INFORMATION UNAVAILABLE category

Entry point – A WTGS generator system becomes unable to detect WTGS operating data or unable to log to permanent local storage or communicate data to other storage.

Exit point – A WTGS generator system becomes able to detect WTGS operating data and to log to permanent local storage or communicate data to other storage.

– –

Annex A
(informative)
Optional information categories - examples

A.1 General

This annex describes examples of optional information categories proposed to be applied when more detailed information is required in order to address specific information needs. An overview of some possible information categories are depicted in Figure 20.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1		
			PARTIAL PERFORMANCE (IAOGPP)	2	Derated	2.1
					Degraded	2.2
		NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3		
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4	Calm Winds IAONGENC	4.1
					Other Environmental IAONGENO	4.2
			REQUESTED SHUTDOWN (IAONGRS)	5		
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6		
		NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7	Response Diagnostic Logistic Failure repair
	PLANNED CORRECTIVE ACTIONS (IANOPCA)		8	7.2, 8.2, 9.2		
	FORCED OUTAGE (IANOFO)		9	7.3, 8.3, 9.3 7.4, 8.4, 9.4		
	SUSPENDED (IANOS)		10	Scheduled Maintenance Planned Corrective Actions Forced Outage	10.1 10.2 10.3	
	FORCE MAJEURE (IAFM)			11		
	INFORMATION UNAVAILABLE (IU)				12	

Figure 20 – Information category overview – mandatory and optional

If further detail is required more optional information categories can be added as underlying categories to the mandatory level 4 and / or to the proposed level 5 categories. All optional information categories shall be located on level 5 or higher in order to be compliant with this technical specification. Priority of optional categories must be assigned as depicted in the example in Figure 20. Priorities of optional categories only apply within its parent information category.

A.2 PARTIAL PERFORMANCE - optional categories

The optional information categories are introduced to further detail the mandatory information category PARTIAL PERFORMANCE as listed below and depicted on Figure 21.

- **Derated** – as defined in clause A.2.1
- **Degraded** – as defined in clause A.2.2

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1		
			PARTIAL PERFORMANCE (IAOGPP)	2	Derated	2.1
					Degraded	2.2

Figure 21 – Optional categories for PARTIAL PERFORMANCE

In following clauses are the optional information category further specified.

A.2.1 Derated

Definition – The optional information category **Derated** can be used to accumulate time periods when a WTGS is operative and generating at reduced power because of external commands or external constraints.

External constraints would typically include, but are not limited to, power curtailment, grid stability support modes, ancillary services, environmental conditions (temperature, dust, turbulence etc.) or other external factors (noise, shadow, flicker, wake, turbulence etc.).

The **Derated** category is an underlying category of PARTIAL PERFORMANCE and has no predefined underlying optional information categories as depicted in Figure 22.

The **Derated** category is optional.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1		
			PARTIAL PERFORMANCE (IAOGPP)	2	Derated	2.1
					Degraded	2.2

Figure 22 – Derated category

Entry point – An external event or manual intervention prohibits a WTGS from operating at specified active or reactive power level.

Exit point – All external constraints which prohibit a WTGS from operating at a specified active and reactive power level are cleared.

A.2.2 Degraded

Definition – The information category **Degraded** can be used to accumulate time periods when a WTGS is operative and generating power with a reduced performance because of internal constraints.

Internal constraints could result from component damage or the need to prevent component damage, e.g. component overheating, vibration levels, bearing failure, converter cooling system failure etc.

The **Degraded** optional information category is an underlying category of PARTIAL PERFORMANCE and has no predefined underlying information categories as depicted in Figure 23.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	GENERATING (IAOG)	FULL PERFORMANCE (IAOGFP)	1		
			PARTIAL PERFORMANCE (IAOGPP)	2	Derated	2.1
					Degraded	2.2

Figure 23 – Degraded category

Entry point – An internal event or manual intervention prohibits a WTGS from operating at a specified active or reactive power level.

Exit point – All internal constraints which prohibit a WTGS from operating at a specified active and reactive power level are cleared.

A.3 OUT OF ENVIRONMENTAL SPECIFICATION - optional categories

The optional information categories are introduced to further detail the mandatory information category OUT OF ENVIRONMENTAL SPECIFICATION as listed below and depicted on Figure 24.

- **Calm Winds** – as defined in clause A.3.1
- **Other Environmental** – as defined in clause A.3.2

The optional information categories are defined in the following clauses.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3		
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4	Calm Winds IAONGENC	4.1
					Other Environmental IAONGENO	4.2
			REQUESTED SHUTDOWN (IAONGRS)	5		
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6		

Figure 24 – Optional categories for OUT OF ENVIRONMENTAL SPECIFICATION

A.3.1 Calm Winds

Definition – The optional information category **Calm Winds** can be used to accumulate time periods when a WTGS is operative but not generating because the wind speed is under the design specification for the minimum wind speed of the turbine.

The **Calm Winds** category is an underlying category of OUT OF ENVIRONMENTAL SPECIFICATION and has no predefined underlying information categories as depicted in Figure 25.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3		
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4	Calm Winds IAONGENC	4.1
					Other Environmental IAONGENO	4.2
			REQUESTED SHUTDOWN (IAONGRS)	5		
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6		

Figure 25 – Calm Winds category

Entry point – The wind speed in the natural environment change to be below the WTGS design specification for minimum wind speed, prohibiting the WTGS from generating.

Exit point – The wind speed in the natural environment rises above the WTGS design specification for minimum wind speed.

A.3.2 Other Environmental

Definition –The optional information category **Other Environmental** is obtained when the WTGS is operative but not generating as one or more conditions of the natural environment are outside the design specifications, other than wind speed being below the design specification for minimum wind speed.

The **Other Environmental** optional information category is an underlying category of OUT OF ENVIRONMENTAL SPECIFICATION and has no predefined underlying information categories as depicted in Figure 26.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	OPERATIVE (IAO)	NON-GENERATING (IAONG)	TECHNICAL STANDBY (IAONGTS)	3		
			OUT OF ENVIRONMENTAL SPECIFICATION (IAONGEN)	4	Calm Winds IAONGENC	4.1
					Other Environmental IAONGENO	4.2
			REQUESTED SHUTDOWN (IAONGRS)	5		
			OUT OF ELECTRICAL SPECIFICATION (IAONGEL)	6		

Figure 26 – Other Environmental category

Entry point – One or more conditions in the natural environment changes to be outside the WTGS design specification, other than the wind speed falling below the design specification for minimum wind speed, prohibiting the WTGS from generating.

Exit point – All conditions in the natural environment are within the design specification of the WTGS, other than the wind speed in the natural environment being above the WTGS design specification for minimum wind speed.

A.4 NON-OPERATIVE - optional categories

The optional information categories are introduced to further detail the mandatory information category NON-OPERATIVE as listed below and depicted on Figure 27.

Optional information categories applicable for SCHEDULE MAINTENANCE, PLANNED CORRECTIVE ACTIONS and FORCED OUTAGE:

- Response time – as defined in clause A.4.1.2
- Diagnostic time – as defined in clause A.4.1.3
- Logistic – as defined in clause A.4.1.4
- Failure repair – as defined in clause A.4.1.5

Optional information categories applicable for SUSPENDED:

- Scheduled maintenance – as defined in clause A.4.2.1
- Planned Corrective Actions – as defined in clause A.4.2.2
- Forced Outage – as defined in clause A.4.2.3

An overview of the optional information categories is depicted in Figure 27.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7	Response Diagnostic Logistic Failure repair	7.1, 8.1, 9.1
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8		7.2, 8.2, 9.2
		FORCED OUTAGE (IANOFO)		9		7.3, 8.3, 9.3 7.4, 8.4, 9.4
		SUSPENDED (IANOS)		10	Scheduled Maintenance Planned Corrective Actions Forced Outage	10.1 10.2 10.3

Figure 27 – Optional categories for NON-OPERATIVE

A.4.1 Outage workflow - optional categories

The following optional information categories can be applied to increase the detail of the following mandatory information categories SCHEDULED MAINTENANCE, PLANNED CORRECTIVE ACTIONS and FORCED OUTAGE. The main purpose for these optional information categories is to provide generic terms for assigning responsibility for various stages of an outage workflow.

An overview of the optional information categories is depicted on Figure 28.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7	Response Diagnostic Logistic Failure repair	7.1, 8.1, 9.1
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8		7.2, 8.2, 9.2
		FORCED OUTAGE (IANOFO)		9		7.3, 8.3, 9.3 7.4, 8.4, 9.4
		SUSPENDED (IANOS)		10	Scheduled Maintenance Planned Corrective Actions Forced Outage	10.1 10.2 10.3

Figure 28 – Optional categories for outage workflow

A.4.1.1 Outage workflow

When an outage category is encountered a breakdown of the outage workflow can be interesting for monitoring the performance of the various parties involved.

The time terms to be observed can be as specified in this sub clause. The overall workflow can be separated into the optional information categories as depicted in Figure 29.

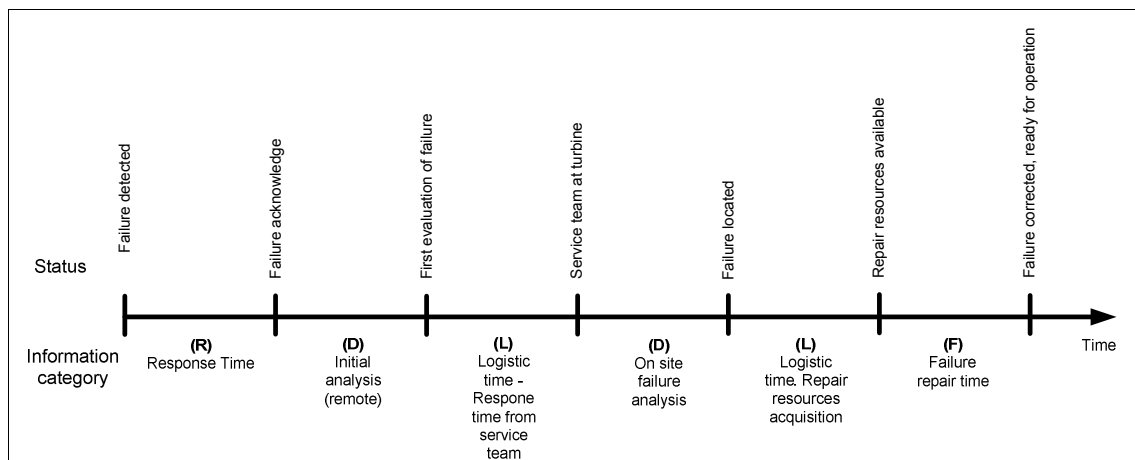


Figure 29 – Workflow breakdown structure

As seen from the schematic workflow the time period from a fault in a WTGS is detected to when the failure is repaired and all alarms / events are cleared can be divided into four underlying optional information categories as listed below.

- Response time (R) – as defined in clause A.4.1.2
- Diagnostic time (D) – as defined in clause A.4.1.3
- Logistic time (L) – as defined in clause A.4.1.4
- Repair time (F) – as defined in clause A.4.1.5

The optional information categories defined are described in further detail in the following sub clauses.

A.4.1.2 Response Time (R)

Definition - This optional information category can be used to accumulate time periods from notification of any event until an action on the event has been initiated.

In the workflow breakdown this category could cover, but is not limited to:

- Failure acknowledge
- Service partner response time for a repair request
- Service team setup
- Waiting time for acceptance to initiate a corrective action

Entry point – An internal fault or external command is received and the WTGS generator system does not automatically return to the operative category.

Exit point – The operator detects and logs fault or status. A WTGS generator system can only exit this category by manual intervention.

A.4.1.3 Diagnostic Time (D)

Definition - This optional information category can be used to accumulate time periods spend to analyse a fault symptom, related measurements and findings indicating a failure and planning corrective action. In the workflow breakdown it covers, but is not limited to:

- Initial analysis
- Remote detailed analysis
- Additional analysis
- Additional clarifications required
- Planning corrective actions
- Approval of corrective actions

Entry point – The operator detects and logs fault or status. The turbine can only enter this mode by manual intervention.

Exit point – The operator has completed analysis and determined required action. A WTGS generator system can only exit this category by manual intervention.

A.4.1.4 Logistic Time (L)

Definition - This optional information category can be used to accumulate time periods used for logistic activities such as, but is not limited to:

- Transportation of tools
- Crane lead time
- Service team set-up
- Ordering support tools
- Ordering spare parts
- Waiting time for resource allocation
- Lead time for tools required
- Lead time for spare parts required
- Waiting time resource allocation

Entry point – The operator has completed analysis and determined required action and has initiated actions such as: orders parts, calls out repair team, etc. A WTGS generator system can only enter this category by manual intervention.

Exit point – All the required actors and equipment are in place for the activities called for by the current diagnostics. A WTGS generator system can only exit this category by manual intervention.

A.4.1.5 Repair Time (F)

Definition – This optional information category can be used to accumulate time periods used for implementation of repair activities such as, but are not limited to:

- Change of a defective sensor
- Change of control software version
- Verification of replaced damage parts
- Inspection or audit related to repairing activity
- Run-in test after finalizing repair activity

Entry point – The repair activity begins either local or remote. A Repair Time information category can only be entered by manual intervention.

Exit point – This optional information category is terminated by manual intervention when the repair activity is completed.

A.4.2 SUSPENDED - optional categories

The following optional information categories can be applied to increase details in the mandatory information category SUSPENDED. The main purpose for the optional information categories focusing on the suspended situation is to provide generic terms for exchange of information on availability and reliability for suspended periods.

An overview of the optional information categories are depicted on Figure 30.

Information categories						
Mandatory Level 1	Mandatory Level 2	Mandatory Level 3	Mandatory Level 4	Mandatory priority	Optional Level 5	Optional priority
INFORMATION AVAILABLE (IA)	NON-OPERATIVE (IANO)	SCHEDULED MAINTENANCE (IANOSM)		7	Response	7.1, 8.1, 9.1
		PLANNED CORRECTIVE ACTIONS (IANOPCA)		8	Diagnostic	
		FORCED OUTAGE (IANOFO)		9	Logistic	7.2, 8.2, 9.2
					Failure repair	7.3, 8.3, 9.3
		SUSPENDED (IANOS)		10		7.4, 8.4, 9.4
					Scheduled Maintenance	10.1
					Planned Corrective Actions	10.2
					Forced Outage	10.3

Figure 30 – Optional categories for SUSPENDED

A.4.2.1 Scheduled Maintenance

Definition - The optional information category **Scheduled Maintenance** covers all situations where a suspension is initiated during a scheduled maintenance activity.

Entry point – This optional information category is entered by manually intervention when a scheduled maintenance task is suspended according to defined conditions.

Exit point – this optional information category is terminated by manual intervention when the conditions suspending the work have been cleared.

A.4.2.2 Planned Corrective Actions

Definition - The optional information category **Planned Corrective Actions** covers all situations where a suspension is initiated during a planned corrective activation period.

Entry point – This optional information category is entered by manual intervention when a planned corrective action is suspended according to conditions defined.

Exit point – this optional information category is terminated by manual intervention when the conditions for suspending the work have been cleared.

A.4.2.3 Forced outage

Definition - The optional information category **Forced Outage** covers all situations where a suspension is initiated during a forced outage.

Entry point – This optional information category is entered by manual intervention when a forced outage situation has occurred.

Exit point – this optional information category is terminated by manual intervention when the conditions for suspending the work have been cleared.

Annex B **(informative)** **Time based availability indicators – examples**

B.1 General

This annex describes examples of how to calculate various measures of availability of a WTGS, based on the information categories defined in this document. Each example of availability is defined in terms of three types of information categories:

- 1) Information Categories considered as Available Time;
- 2) Information Categories considered as Unavailable Time; and
- 3) Information categories not to be considered in the availability calculation.

The constituents of each of the three types of information categories specified above are defined for each measure of availability in its respective clause.

When calculating the measure of availability, the following equation shall be applied:

Availability = $1 - (\text{Unavailable Time}) / (\text{Available Time} + \text{Unavailable Time})$.

B.2 Operational availability (“WTGS user’s view”)

B.2.1 General

Definition – Operational availability is the fraction of a given period of time in which a WTGS is actually generating. Lost operating hours due to any reason are included as unavailability.

B.2.2 Operational Availability algorithm based on mandatory states only

In this definition, time considered as available includes:

- Generating – full performance
- Generating – partial performance

Time considered unavailable include

- Technical Standby
- Out of Environmental Specification
- Requested Shutdown
- Out of Electrical Specification
- Scheduled Maintenance
- Planned Corrective Action
- Forced Outage
- Suspended
- Force Majeure

Time not included in the calculation include:

- Information not available

Note that since no information about the turbine is known in the Information Not Available information categories, these periods are not included as available or unavailable, and are excluded entirely from the calculation. This is the equivalent of assuming availability during those hours is the same as that during the period for which information is available.

B.2.3 Operational Availability algorithm - including optional states

In this definition, hours considered as available include:

- Generating – full performance
- Generating – partial performance
- Out Of Environmental Specification - Calm

Hours considered unavailable include

- Technical Standby
- Out of Environmental Specification - Other
- Requested Shutdown
- Out of Electrical Spec
- Scheduled Maintenance
- Planned Corrective Action
- Forced Outage
- Suspended
- Force Majeure

Hours not included in the calculation include:

- Information not available

The use of the optional states “Out Of Environmental Specification - Calm Winds” and “Out Of Environmental Specification – Other Environmental” allows for a distinction to be made between lost operating hours due to unavailable wind resource, and those hours lost due to other operating conditions being beyond the design specifications of the turbine. This performance metric is not penalized by low winds.

B.2.4 Turbine Operational Availability algorithm - including optional states

In this definition, hours considered as available include:

- Generating – full performance
- Generating – partial performance
- Out Of Environmental Specification Calm

Hours considered unavailable include

- Technical Standby
- Out of Environmental Specification Other
- Scheduled Maintenance
- Planned Corrective Action
- Forced Outage
- Suspended
- Force Majeure

Hours not included in the calculation include:

- Requested Shutdown
- Out of Electrical Spec
- Information not available

Turbine operational availability differs from operational availability in that categories generally beyond the control of the turbine are excluded from consideration. Turbine performance is not being evaluated during hours where the operator has requested a shutdown, an electrical connection is not available, or a force majeure event has occurred.

B.3 Technical Availability (“WTGS manufacturer’s view”)

B.3.1 General

Definition – Technical Availability is the fraction of a given period of time in which a WTGS is operating according to its design specifications.

B.3.2 Technical Availability – mandatory states only

In this definition, time considered as available includes:

- Generating – full performance
- Generating – partial performance
- Technical Standby
- Out of Environmental Specification
- Requested Shutdown
- Out of Electrical Specification

Time considered as unavailable include

- Planned Corrective Action
- Forced Outage

Time not included in the calculation include:

- Scheduled Maintenance
- Suspended
- Force Majeure
- Information not available

Annex C (informative) Verification scenarios – examples

C.1 General

This annex is intended to illustrate the application of the indicators shown in Annex B to the information model described in the main body of this technical specification.

Each scenario consists of a time line covering one calendar week of events that may typically occur at a WTGS. The scenarios are described in the following clauses.

For each scenario, time is distributed into the mandatory information categories are depicted in graphical form in Figure 31 according to each verification scenario. Colours indicates how the individual mandatory information categories are included in the availability calculations, with green indicating that time is included in the period hours as available, red indicating that time is included in the period hours as unavailable and grey indicated those hours are excluded from the period hours and are not included in the calculation of the performance metric.

	Mandatory - Information categories												Availability = 1 - unavl./ (avl. + unavl.)		
<u>MEANING OF COLORS:</u> GREEN = included in period hours as available RED = included in period hours as unavailable GREY = excluded from period hours	full performance (IAOGFP)	partial performance (IAOGPP)	technical standby (IAONGTS)	out of environ spec (IAONGEN)	requested shutdown (IAONGRS)	out of electrical spec (IAONGEL)	maintenance (IANOSM)	plan corrective action (IANOPCA)	forced outage (IANOFO)	suspended (IANOS)	force majeure (IAFM)	information unavailable (IU)		Operational Availability (B.2)	Technical Availability (B.3)
Operational Availability														X	
Technical Availability															X

Figure 31 – Verification scenarios – time allocation to information categories

The availability for the period is then calculated in general as follows:

$$\text{Availability} = 1 - \text{Unavailability} = 1 - \frac{\text{unavailable hours}}{\text{available hours} + \text{unavailable hours}}$$

For each scenario, these availability performance metrics are calculated, according to the definitions in Annex B, each with a different perspective on availability performance measurement, as summarized below.

Operational Availability: This is primarily an operator's or user's view of a wind turbine system as a whole and measures how often the asset was actually generating power and revenue. The reasons for allocation of the lost operating hours are less important than the overall view that operation and production have been lost. This is calculated as specified in Annex B, section B.2

Technical Availability: This is primarily the manufacturer's view of a wind turbine and measures how often a wind turbine operated as it was intended to operate. Lost production

due to maintenance as specified, environmental conditions outside the specifications, standby for internal checks, etc are not considered as unavailable in the definition. This is calculated as specified in Annex B, section B.3.

In scenario 1.1 in Figure 32 where the wind turbine has operated at full power for a continuous week of 168 hours, these metrics are each 100%, as expected.

C.1.1 Scenario 1 – communication aspects

<div>MEANING OF COLORS:</div> <div>GREEN = included in period hours as available</div> <div>RED = included in period hours as unavailable</div> <div>GREY = excluded from period hours</div> <div>Operational Availability</div> <div>Technical Availability</div>			Mandatory - Information categories														
			full performance (IAOGFP)	partial performance (IAOGPP)	technical standby (IAONGTS)	out of environ spec (IAONGEN)	requested shutdown (IAONGRS)	out of electrical spec (IAONGEL)	maintenance (IANOSM)	plan corrective action (IANOPCA)	forced outage (IANOFO)	suspended (IANOS)	force majeure (IAFM)	information unavailable (IU)		Operational Availability (B.2)	Technical Availability (B.3)
1. information category			Comments														
1,1	turbine produces power all week	Distribution of time (weekly hours) across information states	168	0	0	0	0	0	0	0	0	0	0	0	100,0%	100,0%	
1,2	turbine has 10 hours before all communication is lost	turbine is 100% available during the 10 known hours	10										158		100,0%	100,0%	
1,3	turbine runs 5 hours, has 1 hr fault and then runs again 4 hours before all communication is lost	if the Information Unavailable state were included in the period time, availability would be 99.4%, an assumption that the turbine was availability all those hours	9								1		158		90,0%	90,0%	
1,4	an earlier gearbox fire has destroyed all communication to the unit. There is no on-line information available	A forced outage, the state is known, but manual entry needed	0								168				0,0%	0,0%	

Figure 32 – Verification scenarios – communication aspects

The communications scenarios illustrate the importance of excluding from the calculation time where information about the turbine state is unknown. In scenario 1.3, if the 158 hours of unknown state were included in the period time, the operational and technical availability would increase to 99.4%. However, it is not known whether the turbine was available or unavailable during this time period, and these hours must be excluded from the calculation.

This essentially extrapolates the measured availability metric throughout the period when information is unavailable.

Note that the loss of electronic or on-line communication does not necessarily imply information is unavailable. As shown in scenario 1.4, the status of a turbine may in some instances need to be manually entered, or data corrected when a state becomes later known.

Wind turbines with local information storage could have a higher availability than wind turbines without local information storage. In addition local information storage in a wind turbine might facilitate a more correct picture of the availability metrics.

C.1.2 Scenario 2 – partial operational aspects

MEANING OF COLORS: GREEN = included in period hours as available RED = included in period hours as unavailable GREY = excluded from period hours Operational Availability Technical Availability			Mandatory - Information categories												Operational Availability (B.2)	Technical Availability (B.3)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
			full performance (IAOGFP)	partial performance (IAOGPP)	technical standby (IAONGTS)	out of environ spec (IAONGEN)	requested shutdown (IAONGRS)	out of electrical spec (IAONGEL)	maintenance (IANOSM)	plan corrective action (IANOPCA)	forced outage (IANOFO)	suspended (IANOS)	force majeure (IAFM)	information unavailable (IU)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														

Figure 33 – Verification scenarios – partial operational aspects

The scenarios depicted in Figure 33 demonstrate that for time-based availability measurements, generating at partial capacity does not affect the availability calculation, and that generating reactive power only, per the defined information category, is also considered partial generation.

C.1.3 Scenario 3 – maintenance aspects

<div>MEANING OF COLORS:</div> <div>GREEN = included in period hours as available</div> <div>RED = included in period hours as unavailable</div> <div>GREY = excluded from period hours</div> <div>Operational Availability</div> <div>Technical Availability</div>			Mandatory - Information categories														
			full performance (IAOGFP)	partial performance (IAOGPP)	technical standby (IAONGTS)	out of environ spec (IAONGEN)	requested shutdown (IAONGRS)	out of electrical spec (IAONGEL)	maintenance (IANOSM)	plan corrective action (IANOPCA)	forced outage (IANOFO)	suspended (IANOS)	force majeure (IAFM)	information unavailable (IU)		Operational Availability (B.2)	Technical Availability (B.3)
3. maintenance			comments														
3,1	8 hours of scheduled maintenance, within spec for expected maintenance duration.	Technical availability is not affected by maintenance since it is per design, but operational availability will increase with reducing maintenance needs	160						8						95,2%	100,0%	
3,2	8 hours of scheduled maintenance must be extended 4 hours to replace a bearing found to be near failure	manual entry needed for excess time, which is considered a forced outage.	156						8	4					92,9%	97,5%	

Figure 34 – Verification scenarios – maintenance aspects

In scenarios depicted in Figure 34 it is clear that maintenance affects operational availability, but not technical availability, as it is planned and scheduled. Wind turbine designs which require less maintenance, will have higher measured operational availabilities. According to the definitions and priorities established in this technical specification, planned corrective actions, have a higher priority than maintenance, and a manual data entry may be needed to allocate time to planned corrective action after the scheduled maintenance is completed in scenario 3.2.

C.1.4 Scenario 4 – operational aspects

			Mandatory - Information categories												Operational Availability (B.2)		Technical Availability (B.3)	
			full performance (IAOGFP)	partial performance (IAOGPP)	technical standby (IAONGTS)	out of environ spec (IAONGEN)	requested shutdown (IAONGRS)	out of electrical spec (IAONGEL)	maintenance (IANOSM)	plan corrective action (IANOPCA)	forced outage (IANOFO)	suspended (IANOS)	force majeure (IAFM)	information unavailable (IU)				
MEANING OF COLORS:																		
GREEN = included in period hours as available																		
RED = included in period hours as unavailable																		
GREY = excluded from period hours																		
Operational Availability																X		
Technical Availability																	X	
4. Operations		comments																
4,1	Gusty high winds exceed cut out speed for 5 hrs	turbines with higher cut out speeds will report higher operational availability, same technical availability	163			5										97,0%	100,0%	
4,2	turbine has a failed part in a lightning storm and the unit could not be entered for 20 hrs, before the 4 hour repair is completed. The week also includes a 40 hour grid outage	definitions handle each point of view	104					40			4	20				61,9%	96,3%	
4,3	unit has to untwist 6 time at 10 min each time		167		1											99,4%	100,0%	
4,4	A gearbox pump failure causes 10 hrs of down time and while the crew is there they do a planned retro on a control card in the top box for 2 hours more	repair switch and manual entry needed	156							2	10					92,9%	92,9%	
4,5	a lightning strike over the spec causes the turbine to come off line half way through the week	manual entry needed. The unit will see this as a fault. Reporting 100% available seems odd. The turbine could be more tolerant of lightning	84										84			50,0%	100,0%	
4,6	A unit if down all week due to a gearbox failure. 20 hrs of regular scheduled maintenance is done during this time	Down time is a higher priority and you cannot enter maintenance from this state	0								168					0,0%	0,0%	

4,7	blade icing is detected and unit shuts down for 10 hours. During this time, cable untwist and other system checks are performed for 2 hours	out of environmental spec is higher priority. Cannot go to standby from there.	158			10										94,0%	100,0%
4,8	There is a 2 day grid outage. During this time, 4 hours of maintenance are performed, winds exceed specs for 8 hours, and a planned repair is done for 2 hours	out of electrical spec is higher priority than out of environmental, lower than maintenance and repair	120					42	4	2						71,4%	98,8%
4,9	On an offshore unit, a generator fails just 5 hours into the week, but rough seas prevent access the entire rest of the week	Technical availability is reported at 100%	5									163				3,0%	100,0%
4,10	bat diurnal patterns cause the unit to be shut down for 2 hours each day		154				14									91,7%	100,0%
4,11	turbine faults offline for an overtemp. pitch motor and restarts after a 2 hour cooling period. This happens 10 times	cooling is recovery from a design issue - forced outage time	148								20					88,1%	88,1%
4,12	2 hours into a repair of a failed part, lightning and high winds stop all work for 16 hours than it resumes and is completed in 2 more hours	Suspend is higher priority than forced outage. manual entry needed. The unit will see this as a fault	148								4	16				88,1%	97,4%

Figure 35 – Verification scenarios – operational aspects

The operational scenarios depicted in Figure 35 more fully illustrate the distinction between operational availability and technical availability to the specifications, and the usefulness of these metrics in assessing overall availability performance. In scenario 4.1, for example, the wind turbine shuts down as expected for winds which exceed the maximum design limit. Although this is per design, from the operator's viewpoint of the wind turbine and system, the unit is unavailable, causing lost operating hours. Units with lower cut-out speeds will have comparable technical availability, but lower operational availability.

Scenario 4.2 illustrates the use of priorities and definitions to handle complicated combinations of events. Note that in scenario 4.6, performing planned maintenance during a forced outage is a part of effective operations, but the forced outage is a higher priority and the unit remains unavailable.

Scenario 4.9 highlights the difficulty in accounting for safety suspension hours. From the operator's system view, the unit is clearly unavailable, and while the lost hours contribute to wind turbine unavailability since the cause of the initial forced outage was a part failure, the safety suspension prevent this condition from being corrected, extending the forced outage. The technical availability metric is not charged with this lost operating time. However, to report the unit as 100% technically available during this time period is an apparent contradiction to the low operational availability.

C.1.5 Scenario 5 – grid / electrical network aspects

			Mandatory - Information categories															
			full performance (IAOGFP)	partial performance (IAOGPP)	technical standby (IAONGTS)	out of environ spec (IAONGEN)	requested shutdown (IAONGRS)	out of electrical spec (IAONGEL)	maintenance (IANOSM)	plan corrective action (IANOPCA)	forced outage (IANOFO)	suspended (IANOS)	force majeure (IAFM)	information unavailable (IU)		Operational Availability (B.2)	Technical Availability (B.3)	
MEANING OF COLORS:																		
GREEN = included in period hours as available																		
RED = included in period hours as unavailable																		
GREY = excluded from period hours																		
Operational Availability			GREEN	GREEN	RED	RED	RED	RED	RED	RED	RED	RED	RED	RED	RED	RED	X	
Technical Availability			GREEN	GREEN	GREEN	GREEN	GREEN	GREEN	GREY	RED	RED	GREY	GREY	GREY	GREY	GREY		X
5. electrical			comments															
5.1	a unit operates for 80 hrs then is in forced outage for 4 hours. There is a grid outage later in the week	out of electrical spec hours are included as available in turbine availability since the unit is operable.	80					84				4					47,6%	97.6%

Figure 36 – Verification scenarios – grid / electrical network aspects

As shown in Figure 36 scenario 5.1, hours when the system is outside of its electrical design specifications are considered unavailable from the operator's system perspective but not from the wind turbine perspective since this is clearly beyond the control of the wind turbine.

A forced outage, however, is a higher priority, and a unit which is in the forced outage state at the beginning of a grid outage would remain in a forced outage, despite the fact that it is unlikely the unit can be returned to service before the electrical system is brought back in to specification.

C.1.6 Scenario 6 – Environmental aspects

			Mandatory - Information categories												Operational Availability (B.2)		Technical Availability (B.3)	
			full performance (IAOGFP)	partial performance (IAOGPP)	technical standby (IAONGTS)	out of environ spec (IAONGEN)	requested shutdown (IAONGRS)	out of electrical spec (IAONGEL)	maintenance (IANOSM)	plan corrective action (IANOPCA)	forced outage (IANFOFO)	suspended (IANOS)	force majeure (IAFM)	information unavailable (IU)				
MEANING OF COLORS:																		
GREEN = included in period hours as available																		
RED = included in period hours as unavailable																		
GREY = excluded from period hours																		
Operational Availability																X		
Technical Availability																	X	
6. environment			comments															
6,1	Winds are below the cut in speed for 68 hrs in a week	100% technically available, but lost operating hours due to low winds.	100			68										59,5%	100,0%	
6.1a	same as 6.1, but uses optional state "out of environment - calm"	*100% operational availability if the optional state – out of environmental calm winds is included as available. No lost operation due to WTGS														100.0%*	100.0%	
6,2	Winds are only above the cut in speed for 8 hrs in the week, the turbine is faulted for 4 hours and runs for 4 hours	lost hours due to wind speeds outside spec affect operational availability, not technical availability	4			160					4					2,4%	97.6%	
6.2a	same as 6.2, but uses optional state "out of environment - calm"	*97.6% operational availability if the optional state – out of environmental calm winds is included as available.														97.6%*	97.6%	
6,3	Good winds, but temperatures are below operating minimum for 68 hrs	low operational availability ties to lost production due to cold. All out of envir. spec hours could be excluded from availability calculation and availability would be 100%, but this does not reflect lost potential operating hours.	100			68										59,5%	100,0%	
6,4	a unit operates for 80 hrs then is in forced outage for 4 hours and then temperatures drop to -30C and all units stop operation	forced outage and out of environ spec affect operational availability same, but not technical availability	80			84					4					47,6%	97.6%	

6,5	A turbine rated for 30C operation stops operation for 20hrs due to temperatures rising to 35C	turbines designed for higher temperatures will have higher operational availability, but technical availability is 100% per design	148			20										88,1%	100,0%
6,6	A turbine rated for 40C operation continues to operate for 20hrs as temperatures rise to 35C	Operational availability of the better turbine is higher, as expected	168			0										100,0%	100,0%

Figure 37 – Verification scenarios – environmental aspects

The scenarios depicted in Figure 37 review environmental scenarios, primarily the impact on calculated availability metrics of ambient temperatures and wind speed above or below the design specification of the turbine.

Scenario 6.1, for example, illustrates the loss of availability due to low wind speed. Although there is little potential for production, the unit cannot operate outside its design limits and is therefore unavailable to the operator, but is fully available technically. This apparent contradiction is resolved through the use of the optional state for out of environmental specification – calm. Similarly, when the ambient temperature is above or below the design limit, the wind turbine is also operationally unavailable, but technically available.

Wind turbines which through better design have broader operating ranges of wind speed and ambient temperature, which have higher operational availability, as expected since they will likely actually operate for more hours, though both might have the same technical availability according to their respective designs. This is shown in scenarios 6.5 and 6.6.